CENTRAL INTELLIGENCE AGENCY

INFORMATION REPORT

SECRET
SECURITY INFORMATION

25X1

COUNTRY	USSR (Kalinin Oblast)/Germany	REPORT	
SUBJECT	Flame Temperature Measuring Apparatus	DATE DISTR.	10 June 1953
		NO. OF PAGES	6
DATE OF INFO.		REQUIREMENT	
PLACE ACQUIRED		REFERENCES	

25X1

25X1

This is UNEVALUATED Information

THE SOURCE EVALUATIONS IN THIS REPORT ARE DEFINITIVE.
THE APPRAISAL OF CONTENT IS TENTATIVE.
(FOR KEY SEE REVERSE)

25X1

25 YEAR RE-REVIEW

372

SECRET

STATE	#x	ARMY	#x	NAVY	#x	AIR	#x	FBI		AEC		OSI ev	x		

25X1

(Note: Washington Distribution Indicated By "X"; Field Distribution By "#".)

[redacted] 25X1

ROCKET FLAME RESEARCH CONDUCTED AT DRESDEN

Methods

1. [redacted] the task of building equipment for the optical investigation of rocket flames and carrying out measurements. The construction was to be carried out in the Scientific Photographic Institute (a section of University of Dresden) in Dresden; measuring was to be done on the test stand in Kummersdorf. 25X1

2. The research was carried out employing the following method:

   a. A photograph of the flame was made by using the light radiated by the flame. Two pictures were made at the same time, one with violet light; the other with infra-red light. The picture with violet light (400-450 millimicrons) indicates the points of the flame where combustion is still taking place. The picture with infra-red light (950 millimicrons) shows the hot combustion products. By comparison of the two pictures, it is possible to determine qualitatively the zones in the flame in which a reaction still occurs. The picture taken with infra-red light was evaluated photometrically, and the relative temperature was determined.

   b. A determination of a single temperature at a particular place in the flame was made by means of the line reversal method. According to this method an image of a source of light which has a uniform luminous area (a ribbon source or a point source) is produced within the flame. By addition of a metal (sodium) the flame emits a line spectrum which can be observed through the spectral apparatus. [See sketch on page 5.]

3. It is possible to determine the luminous density in the vicinity of the line by the black body temperature of the source of light (i.e.Bs.). The luminous density of the line (B1), is composed of the luminous density of the flame Bf and that of the source of light in the line (i.e.Bs(1-d)), which means the fraction of absorption of the flame in the line.

If the luminous density of the source of light is so regulated that the line disappears in the spectrum (i.e. if it is neither brighter nor darker than the surrounding area of the line "reversal point"), then the temperature of the flame is equal to the black body temperature of the source of light.

According to the law of Kirchhoff, $Bf = Bsf$ times α (Bsf is the luminous density of a black body at the flame temperature). Therefore since the luminous density in the vicinity of the line is Bs and the luminous density of the line $B1 = Bs\,(1-\alpha)\ Bfs\,\alpha$. Both luminous densities are equal (the reversal point) if $Bs = Bs\,(1-\alpha)\ Bfs\,\alpha$. Therefore $Bs = Bfs$.

[redacted] 25X1

4. For measurement of rocket flames, it is necessary to carry out the measurement in a short time, especially if several measurements are to be carried out on one burning process. For that purpose, the following method was used [see sketch on page 5]. By use of a gray wedge, which is pictured at the aperture of the spectrograph, the luminous density of the source of light is varied vertically to the spectrum, [see sketch on page 5]. On one end the line is darker, and on the other, brighter, than the surrounding area. The point where it is as bright as the surrounding area corresponds to the reversal point. If the density of the gray wedge which corresponds to the reversal point and the black body temperature of the source of light are known, the flame temperature can be calculated. One picture required approximately three seconds. The accuracy of the reading was approximately 20° K.

Results of Research at Dresden

5. With the equipment produced in Dresden, measurements were carried out in Kummersdorf in the spring of 1940 on a 1-ton aggregate according to the two methods described below as a and b.

a. Method a showed that, at the edge of the flame, burning was still taking place, but that at a greater distance, only the hot combustion gases were radiating. At the center of the flame a higher temperature was measured than at the edges.

b. Method b showed a temperature of about 1900-2000° K.

6. The experiments showed that the method is feasible for temperature measuring of rocket flames. Difficulties became apparent through the strong concussions of the equipment and because the lens became wet as a result of condensation of steam.

NATURE OF RESEARCH AT OSTASHKOV

7. [redacted] 25X1
A theoretical experiment, the object of which was the measuring of the temperature within inhomogeneous flames, was conducted. For that purpose several temperature distributions within hypothetical flames were assumed at random and the temperature, which was to be measured by the line reversal method, was determined. In general, the result does not agree with the mean temperature, but rather corresponds with the temperature of that side of the flame which is farthest away from the source of light. Later, an apparatus with similar dimensions was built which corresponded in principle to the one shown [see sketch on page 5]. Special emphasis was placed on stability by use of steel supports. The apparatus was tested with the flame of a small gasoline burner and worked satisfactorily. However, the apparatus was not used for measuring rocket flames because apparently there was no need for it.

Later, the apparatus was even taken apart and some of the components used for different purposes.

8. Technical details of flame temperature determination procedure were as follows:

a. Densitometer measurements of the infra-red photograph are made and relative numbers assigned to the density of the emulsion blackening.

b. The flame is then divided into circular sections /see figure 1 of sketch on page 6/ and then again into horizontal strips, the circular sections and horizontal strips being coplanar with their plane at right angles to the flame. The infra-red picture and spectrographic reversal measurements are made from this same plane.

c. A set of simultaneous equations is written (as many as the number of circular sections) for the temperature distance products along the borders of the horizontal strips.

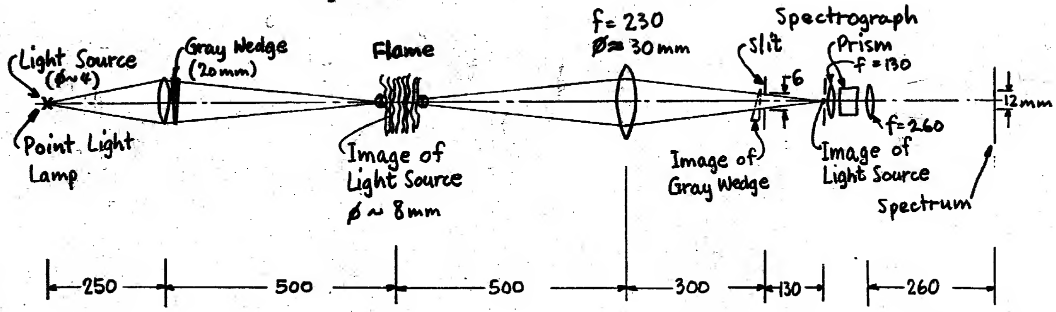
d. Since the number of circular sections are arbitrarily set, depending on degree of accuracy desired, the lengths l_1, l_2, l_3, etc. can be calculated from the geometry of the flame. (If circular sections have different radii, areas must be used rather than lengths.)

e. Assuming that the spectrographic reading is the mean temperature of the line along which the reading is taken and assuming that the flame is uniform in 0 (i.e. uniform temperature within a given circular ring), the temperature at all parts of that plane are easily calculated. The infra-red picture provides the relative data necessary to extend the calculations to other planes of the flame. All emulsion densitometer readings were interpreted with the use of the Wien Black Body Radiation curve to interpret quantities of infra-red radiation as indicating flame temperatures.

-SECRET-

IMAGE OF LIGHT SOURCE

Figure 1.



Actual dimensions of the apparatus are not known. Given dimensions are proportional, but approximate.

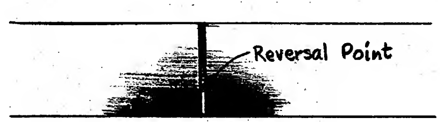
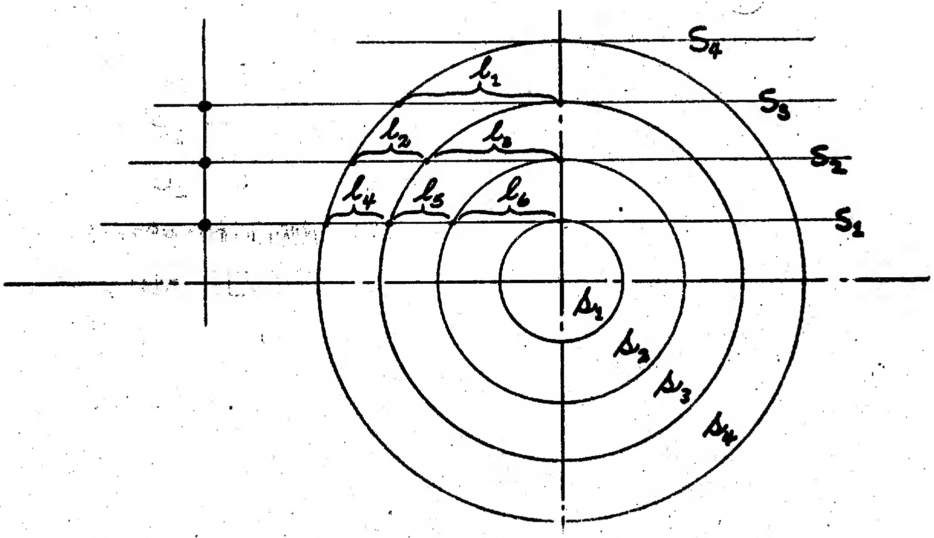


Figure 2.

SECRET -5-

25X1

25X1



$$S_3 = 2l_1 s_4$$
$$S_2 = 2l_2 s_4 + 2l_3 s_3$$
$$S_1 = 2l_4 s_4 + 2l_5 s_3 + 2l_6 s_2$$

End view of Flame (as emitted by Rocket or Jet)

Figure 1.

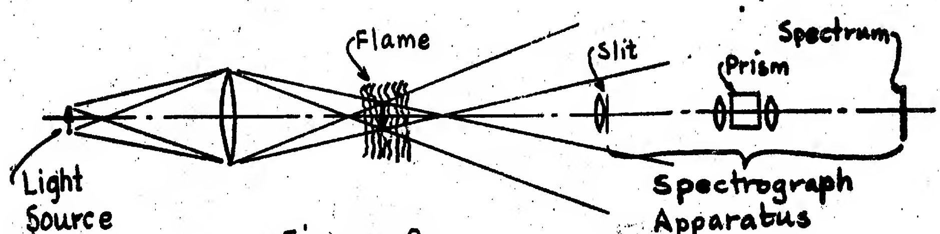


Figure 2.

Determination of the Flame Temperature by the LINE REVERSAL Method.

TEMPERATURE DETERMINATION PROCEDURE